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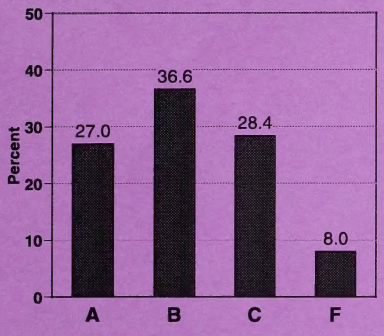
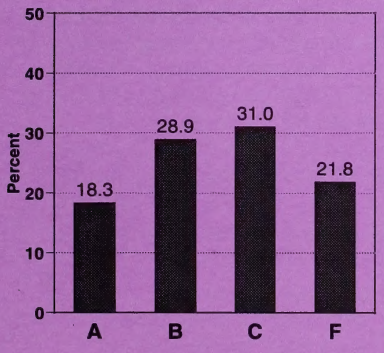
Chemistry 30

Diploma Examination Results
Examiners' Report for June 1997

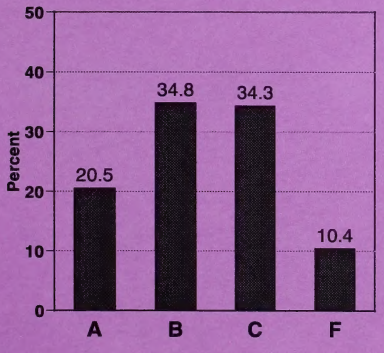
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the June 1997 administration of the Chemistry 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been mailed to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined November, January, June, and August results is published annually.

Description of the Examination

The Chemistry 30 Diploma Examination consists of 44 multiple-choice questions worth 55%, 12 numerical-response questions worth 15%, and two written-response questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 8 141 students in Alberta who wrote the June 1997 examination. This represents a decrease of 84 compared with June 1996.

- 89.6% of the 8 141 students achieved the acceptable standard (a final course mark of 50% or higher).
- 20.5% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 52.6% of the students who wrote the June 1997 examination were female.

- 89.8% of the female students achieved the acceptable standard (a final course mark of 50% or higher).
- 18.3% of these female students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 47.4% of the students who wrote the June 1997 examination were male.

- 89.3% of the male students achieved the acceptable standard (a final course mark of 50% or higher).
- 22.8% of these male students achieved the standard of excellence (a final course mark of 80% or higher).

Students First!
Student Evaluation

Alberta EDUCATION

Provincial Averages

- The average school-awarded mark was 69.0%.
- The average diploma examination mark was 63.1%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 66.4%.

Approximately 8.6% of the students who wrote the examination in June 1997 and received a school-awarded mark had written at least one other Chemistry 30 Diploma Examination during the January 1996 to January 1997 period. This sub-population (702) did not do as well on the examination (58.2%) as the population (7 439) who first wrote the Chemistry 30 examination (63.5%) in June 1997. However, the group of students who rewrote the chemistry examination increased their exam score, on average, by 8.6%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students capable of achieving the acceptable standard will obtain a minimum mark of 50%, and students capable of achieving the standard of excellence will obtain a minimum mark of 80%. Future examinations will continue to require students to demonstrate clarity in their thinking and an understanding of concepts by applying their knowledge to new and novel situations. Students will also continue to be required to present their answers in a clear, concise, organized fashion and to respect the conventions of the mode of communication selected.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer.

For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge:

- GLE 1 Quantitatively Predicting Outcomes
- GLE 2 Qualitatively Analyzing Systems
- GLE 3 Relationships in Energy Transfer
- GLE 4 Relationships in Electron Transfer
- GLE 5 Relationships in Equilibrium Systems
- GLE 6 Relationships in Proton Transfer

Skills:

- SPSC Scientific Process Skills and Communication Skills

Science, Technology, Society:

- STS Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPSC	STS
MC 1	D	0.895	✓		✓					
NR 1	35.1	0.714	✓		✓				✓	✓
MC 2	C	0.595		✓	✓					✓
NR 2	*	0.511	✓		✓				✓	✓
MC 3	A	0.710		✓	✓	✓			✓	✓
NR 3	2413	0.679	✓		✓				✓	
MC 4	C	0.743	✓		✓				✓	✓
MC 5	C	0.873		✓	✓					✓
MC 6	B	0.613	✓		✓				✓	
MC 7	C	0.638	✓		✓				✓	✓
MC 8	C	0.754		✓	✓	✓				✓
MC 9	D	0.795		✓	✓		✓			✓
MC 10	C	0.544		✓	✓	✓	✓		✓	✓
MC 11	A	0.804		✓	✓	✓			✓	

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPSC	STS
MC 12	D	0.636		✓	✓	✓				✓
MC 13	A	0.734		✓	✓	✓				
MC 14	B	0.718	✓			✓			✓	✓
MC 15	B	0.541	✓			✓			✓	✓
MC 16	**	0.720	✓			✓			✓	✓
MC 17	A	0.511		✓		✓		✓	✓	✓
MC 18	B	0.543		✓		✓			✓	✓
MC 19	A	0.807		✓	✓	✓			✓	✓
MC 20	D	0.646		✓		✓				✓
MC 21	D	0.712		✓		✓			✓	✓
MC 22	A	0.835		✓	✓	✓				
MC 23	D	0.670		✓		✓				
MC 24	C	0.631		✓		✓			✓	
NR 4	4646	0.807	✓			✓			✓	
MC 25	A	0.752		✓		✓			✓	
NR 5	2413	0.889		✓		✓			✓	
NR 6	2.32	0.475	✓			✓			✓	
MC 26	B	0.893	✓				✓		✓	✓
MC 27	B	0.932		✓			✓			✓
MC 28	D	0.268	✓				✓		✓	✓
MC 29	A	0.342		✓			✓	✓		✓
NR 7	32.3	0.185	✓			✓			✓	✓
MC 30	C	0.808		✓			✓	✓	✓	✓
MC 31	D	0.810		✓	✓		✓			✓
MC 32	B	0.481		✓			✓		✓	✓
NR 8	2461	0.519		✓		✓			✓	
MC 33	B	0.517	✓				✓		✓	✓
MC 34	C	0.765		✓	✓				✓	✓
NR 9	2	0.904	✓				✓		✓	✓
MC 35	A	0.600		✓		✓		✓	✓	✓
MC 36	C	0.290	✓					✓	✓	✓
MC 37	D	0.487	✓	✓				✓	✓	✓
MC 38	A	0.823	✓					✓	✓	✓
MC 39	A	0.616		✓				✓	✓	
NR 10	1.33	0.576	✓				✓		✓	✓
MC 40	B	0.369		✓				✓	✓	
MC 41	C	0.946	✓					✓	✓	✓
MC 42	B	0.755		✓				✓		
NR 11	1423	0.772		✓			✓	✓		
MC 43	A	0.715		✓			✓	✓		✓
NR 12	33.3	0.663	✓					✓		
MC 44	D	0.455		✓				✓		
WR 1	–		✓	✓	✓				✓	✓
WR 2	–			✓		✓		✓	✓	✓

* NR2: 5.46 if A was selected from MC4; 6.92 if B was selected; 7.82 if C was selected; and 9.28 if D was selected.
** MC16: B if A was selected for MC15; D if B was selected; C if C was selected; and A if D was selected.

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

Machine scored: 37.1 out of 56
Multiple choice: 29.4 out of 44
Numerical response: 7.7 out of 12

Written Response: 13.1 out of 24
Question 1: 6.82 out of 12
Question 2: 6.25 out of 12

General Learner Expectations:

GLE 1	Quantitatively Predicting Outcomes	22.3	out of	35
GLE 2	Qualitatively Analyzing Systems	33.1	out of	58
GLE 3	Relationships in Energy Transfer	19.8	out of	32
GLE 4	Relationships in Electron Transfer	20.0	out of	36
GLE 5	Relationships in Equilibrium Systems	9.4	out of	14
GLE 5	Relationships in Proton Transfer	13.3	out of	27
SPSC	Scientific Process and Communication Skills	34.7	out of	62
STS	Connections in Science, Technology, and Society	34.8	out of	61

Multiple-Choice and Numerical-Response Questions

The following questions were selected for discussion because they exemplify what is required to meet, minimally, the acceptable standard and the standard of excellence.

Students just achieving the acceptable standard were capable of answering questions such as multiple-choice questions 8, 9, 11, 16, 19, 22, 25, 30, 31, 34, 38, and 42, and numerical-response questions 4 and 11.

*Use the values selected from **Multiple Choice 15** to answer **Multiple Choice 16**.*

16. The titration required 55.0 mL of 0.100 mol/L $KMnO_{4(aq)}$ to react completely with the $Fe^{2+}_{(aq)}$. The mass of iron in the ore sample was

A. 0.123 g
B. 0.307 g
C. 0.768 g
D. 1.54 g

For example, in **multiple-choice question 16**, most students (78.5%), when given a balanced chemical equation for the reaction, could perform stoichiometric calculations to determine the mass of iron. However, only 54.1% of all students were able to correctly balance the equation in multiple-choice question 15. Thus, had multiple-choice question 16 not been asked in a linked form, most students would not have been able to answer it. Of students who achieved the acceptable standard, the majority (82.1%) had success on this question, as did 96.8% of those who achieved the standard of excellence and 53.3% of those who did not achieve the acceptable standard.

The results from this question suggest that students who do not achieve the acceptable standard have difficulty in performing routine stoichiometric calculations that involve more than one step. Students capable of performing multi-step stoichiometric calculations or using the label analysis method will achieve the acceptable standard, provided that they are not required to combine different processes, such as balancing a chemical equation for a reaction and performing stoichiometric calculations.

Use the following information to answer the next question.

Large amounts of ammonia are used in the production of nitric acid, $HNO_{3(aq)}$. One step in the production of nitric acid is represented by the equation

$$4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$$

34. The change in enthalpy for the reaction is

A. –105.5 kJ
B. –197.7 kJ
***C.** –905.6 kJ
D. –1274.4 kJ

In **multiple-choice question 34**, most students (76.5%) were able to utilize Hess' Law to determine the enthalphy change for a reaction, given a balanced chemical equation. Of students attaining the standard of excellence, 96.9% answered this question correctly, as did 80.0% of students attaining the acceptable standard. The most common error for students was to add rather than subtract the sum of the molar heats of formation of the reactants and, as a result, select D as their answer. Of students who did not attain the acceptable standard, 49.4% had difficulty with this question, primarily because they ignored the molar coefficients and selected A or B as their answer.

The results from this question and multiple-choice question 16 suggest that a major difference between those students who do not achieve the acceptable standard and those who do is the ability of the latter group to recognize the value of the information provided to them.

28. At equilibrium, if the $[O_{2(g)}] = [N_{2(g)}]$, then

A. $[NO_{(g)}] = [N_{2(g)}]$
B. $[NO_{(g)}] > [N_{2(g)}]$
C. $[NO_{(g)}] = 2[N_{2(g)}]$
***D.** $[NO_{(g)}] < [N_{2(g)}]$

Students just achieving the standard of excellence were capable of answering questions such as multiple-choice questions 28, 40, and 44, and numerical-response question 7.

For example, in **multiple-choice question 28**, of those students achieving the standard of excellence, 49.3% were able to devise a strategy to solve this question. They either picked and substituted values into an equilibrium expression, or they used unknowns to determine that the concentration of nitrogen would be greater than the concentration of nitrogen monoxide. Most students appear to have had no strategy for solving this question, but instead resorted to guessing. Of all students answering this question, only 26.8% did so correctly.

The results from this question suggest that students who attained the standard of excellence did so because they were able to manipulate successfully both symbols and numerical values. They were able to determine the relative magnitudes of several reagents in order to arrive at a valid conclusion.

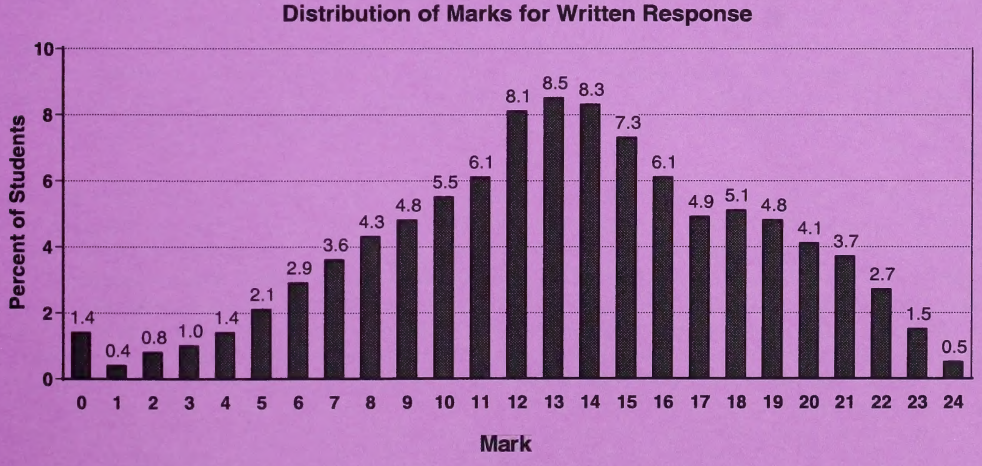
29. In aqueous solution, ammonia is a

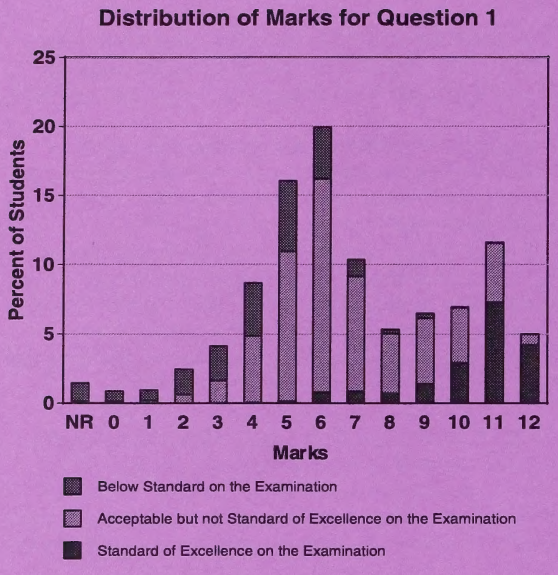
***A.** weak base
B. strong base
C. weak triprotic acid
D. weak monoprotic acid

Multiple-choice question 29 was answered very poorly . Only 34.2% of all students were able to identify ammonia as a weak base. All students should be able to recognize common bases, such as ammonia, through common experience or by utilizing the Relative Strengths of Acids and Bases table in the Chemistry Data Booklet. The results of this question suggest that all students are having difficulty distinguishing between the concepts of strength and concentration.

Written-Response Questions

Of all the students who wrote the exam, 59.6% received a mark of 12 or higher out of 24. The average mark on the written-response questions was 13.1 or 54.6%.





Written-response question 1 was not answered as well as expected. The question was selected to measure students' ability to compare qualitatively and quantitatively the difference in energy derived from two edible chemical compounds.

Overall, students attempted all parts of the question and were successful in answering the open-ended diet-application part of the question. Students identified good, common-sense concerns for the diet choices people might make. Significant digits, in the calculation part of the question, were very well done. The most common error was the incorporation of a mass value into the calorimeter calculation for enthalpy change. Students did not differentiate heat capacity from specific heat capacity when selecting an appropriate formula or values. The majority of the student responses did not indicate that the enthalpy changes were exothermic. Students may have forgotten to indicate the energy direction, that is, the assigning of a negative to the enthalpy value, or they may have assumed all combustion reactions were exothermic.

Students who did not achieve the acceptable standard were expected to score up to 6, and 84.9 % did so. They averaged 4.13 by knowing the difference between stearic acid (fat) and sugar as diet energy sources. These students commonly had a problem with the enthalpy calculation. They chose the familiar "$q = mc\Delta t$" formula and tried to make it work by substituting inappropriate mass values into the expression. Many students had trouble suggesting a viable method to determine the kJ/g energy content of fat and sugar. Students not achieving acceptable standard consistently exhibited poor organization and writing skills. Insufficient attention to detail, especially units, contributed to their inability to calculate correctly the kJ/g enthalpies for the two substances. Some students stated that the energy changes were endothermic and therefore required energy to "burn off" the fat or sugar. These students did, however, identify a variety of relevant, common-sense answers to the diet selection part of the question, citing such concerns as tooth decay, heart disease, and diabetes.

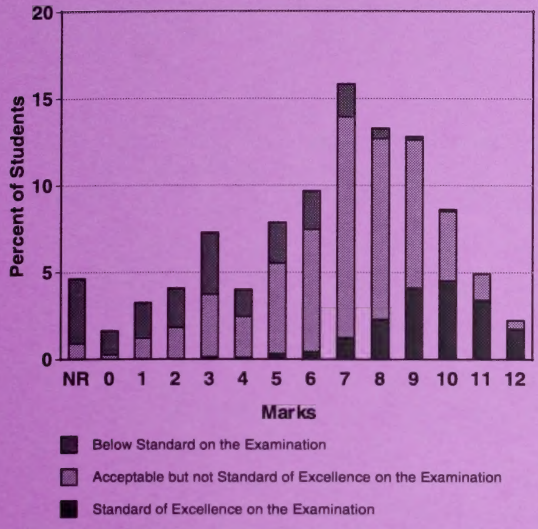
Students who did achieve the acceptable standard but not the standard of excellence on the examination were expected to score in the range of 6 to 9, and 54.7 % of them did so. They averaged 6.72 by calculating the molar enthalpy in kJ/mol for each of the substances and by making a consistent diet choice based on their enthalpy values. Many students indirectly calculated the heat capacity when determining the molar enthalpy. A common error made by students was the use of 1.0 g in the enthalpy calculations. Generally, these students' responses were well organized, with units and significant digits used consistently throughout.

Students who achieved the standard of excellence were expected to score 10 or better, and 78.7 % did so, with 23.0 % attaining a perfect score. They averaged 10.34 by accurately determining the enthalpy for the two substances in kJ/g. These students were able to calculate the enthalpy change from a valid formula. Many students employed a unit analysis method to determine the kJ/g enthalpies. These students demonstrated an intuitive approach to solving an unfamiliar problem as they did not depend on a "canned" formula. Students' explanations of diet choice included a quantitative comparison as well as the identification of a reasonable health concern. These students exhibited excellent attention to detail in terms of organization and communication skills and seldom lost marks associated with ambiguity or small errors.

The results on this question suggest the importance of teaching the concept of heat capacity used in industrial applications such as bomb calorimeters, in addition to the traditional specific heat capacity concept and calculations. The consistent use of units throughout calculations helped students solve this problem in kJ/g. Clearly, reading carefully and accurately for desired units appears to be problematic. In general, students attempted all parts of the problem and were therefore eligible for full communication marks.

On this 12-mark question, the average mark was 6.82, or 56.8 % of the available mark.

Distribution of Marks for Question 2



Written-response question 2 was answered better than was expected. The question was selected to measure students' ability to determine the reaction mechanism for a common household product. They were required to devise a reaction equation from reagents they had identified. Students could correctly answer the question from an acid–base, reduction–oxidation, or thermochemistry perspective.

Students who did not achieve the acceptable standard were expected to score up to 5, and 60.1 % met this expectation. They averaged 3.04 because they understood that the colour-change mechanism involved either an acid–base reaction or a spontaneous redox reaction. Safety was partially addressed, and most students attempted the key component of the question. Students who identified a valid indicator often did not provide an explanation or reaction equation to support their choice. Many students had difficulty choosing a suitable reagent for the coloured marker. They often ignored the desired colour change and selected indicators such as HBb or HPh for the red-to-yellow colour change. Many students considered dilution as a method. Water was commonly identified as the colourless-marker compound. Redox reactions, when used, were poorly done, and students using them failed to recognize potentially harmful chemicals such as cyanide or dichromate compounds as being dangerous for use by small children. Most safety issues identified by the students were not pH-related, but rather dealt with the concern that the marker be non-toxic. Students who were successful in selecting a colour change species seldom provided a valid reaction mechanism or suitable reaction equation. They did not understand that the indicator colour was dependent on the solution it was placed in. These students revealed a common chemistry misconception that "acids can hurt but bases are safe." Flame, ion, and indicator colours were frequently used interchangeably by students who did not achieve the acceptable standard. These student responses were poorly organized and contained many errors in convention.

Students who achieved the acceptable standard but not the standard of excellence were expected to score from 6 to 9. In total, 64.5 % of these students met this expectation, with the average mark being 6.74. They could select a species or indicator for the designated colour change and provide appropriate support for their choices. Students identified potential colourless overwriter-pen solutions. Many students appeared to know more than they expressed on paper. For example, they did not provide specific reactions or reagents but illustrated a good understanding of the reaction mechanism. Students recognized that a neutralization reaction was quite likely involved, and they emphasized safety, but not always as a pH-related concern. Students selecting polyprotic indicators had difficulty interpreting the indicator-colour table. Some considered having indicators present in both pens that would react to produce the desired colour change. Frequently, students tried to explain the reaction mechanism without providing an equation. They appear to have missed the concept of proton transfer associated with the

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colour change of an indicator. As in the past, the safety concerns that they identified revealed confusion and misconceptions about solutions, particularly concepts of weak vs. strong, dilute vs. concentrated, and toxic vs. corrosive. These students' responses were generally well organized. Errors in convention such as states of matter and spelling were fairly common.

Students who achieved the standard of excellence were expected to score 10 or better. They averaged 8.99, or 52.7%, for this question, with 9.5% attaining a perfect score. Students achieving the standard of excellence did so because they could successfully identify the two reagents and illustrate a good understanding of the reaction mechanism. Students used pH as an important selection criteria for the reagents in a pen to be used by small children. These students wrote chemical reactions that clearly outlined the reaction mechanism of choice. Many went beyond what was expected and calculated the pH of the marker solution using K_a values. These students presented their answers in a concise, well-written, and organized manner.

The results on this question suggest that most students had difficulty writing Bronsted–Lowry equations for indicators. A number of students chose dichromate because of its orange-red colour. It should be noted that the examination printer produced a more orange graphic than was originally designed; therefore, examination markers accepted any viable reagents corresponding to the orange or red colour change indicated.

Dilution with water or treating water as the acid or base in the colourless marker were common misconceptions held by many students. When discussing household products, students also lacked a practical understanding of what is toxic or safe. Most safety concerns identified by students dealt with the concept of the marker being non-toxic rather than being pH-related. This question could have been appropriately answered from a redox, acid–base or thermochemistry perspective. This question is an STS open-ended question drawing on knowledge from several units. It allowed students to demonstrate their understanding of chemistry to solve a new, practical problem.

On this 12-mark question, the average mark was 6.25 or 52.1% of the available mark.

For further information, contact Marlene McDonald (mmcdonald@edc.gov.ab.ca) or Phill Campbell (pcampbell@edc.gov.ab.ca) at the Student Evaluation Branch at 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.

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